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STUDYING THE EFFECT OF NON- CONVENTIONAL SOURCESON IEEE-30 BUS SYSTEM

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ABSTRACT

Power flow analysis is called as the backbone of power system analysis [1]. In our project, we have built the IEEE-30 bus system using MI-power software package and conducted load flow studies for the created system and the results are compared with the standard system. Further, least generating generators are figured out and these generators are replaced with RES (solar and wind) and load flow studies are done for the same. In our project, we have considered solar as negative load due to following reasons: 1. solar PV cell is not completely developed in MI-power software package. 2. It will have same effect as that of solar. The main aim of our project is to reduce the dependency on the conventional generators and to make eco-friendly operation.

KEYWORDS: MI-power, load flow studies, negative load, hybrid system, wind farms.

I. INTRODUCTION

Earlier in late 1900's majority of the power generation was by conventional sources, while on the other hand non-conventional generators contributed less than 1% of the total power demand [4]. In recent years, it has been estimated that the scarcity of the fossil fuels i.e., coal, uranium, diesel etc. which are resources for conventional generators will occur in next 80 years [3] and also the usage of these fossil fuels is hazardous to the environment. Thus, there is a need to develop systems which incorporate Renewable Energy Resources.

In India, renewable energy potential is high. Energy production by conventional sources is estimated to be about 29.9% of the total installed capacity till 31st January 2017. Out of many renewable energy resources solar and wind are famous and also important. In order to practically deploy the renewable energy sources in the existing power system, we have to simulate the network and study the behaviour of the system.

Load flow studies are conducted to study the behaviour of the system [2]. Various techniques used in load flow studies are Guass-Seidal method, Newton-Rapson method and fast decoupled method [3][5]. In this paper, we have considered fast decoupled method with 25 iterations and have done the load flow studies.

MI-power software is used to simulate the IEEE-30 bus system and load flow study is conducted. Least generating generators are figured out and is replaced with RES, that is negative load in case of solar energy and load flow study is conducted for the same. Later, wind farms are added and the same process is repeated. Soon after that the negative load and wind farms are simultaneously added, load flow studies is done and analysed. Further the change in bus voltages is observed and results are compared with the built-in system. This would help in knowing the merits and challenges when RES replaces the conventional sources.

II. SINGLE LINE DIAGRAM

The single line diagram of IEEE-30 bus system is shown in fig.1.

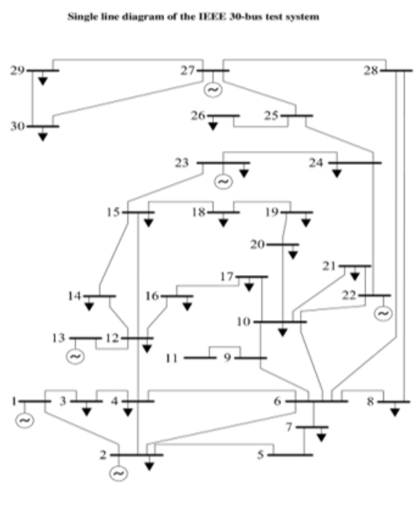

Fig.1 Single line diagram of IEEE 30 bus System

This system consists of 30 buses, 21 loads, 41 transmission lines, six generators and two shunt capacitance. The generator cost and emission coefficients, loads, shunt capacitor and transmission lines are provide in table A.1, A.2, A.3 and A.4 respectively.

Table A.1 Generator data

Gen. No. i	P_i min (MW)	P_i max (MW)	Q_i min (MW)	Q_i max (MW)
1	50	200	-	-
2	20	80	-20	100
3	25	50	-15	80
4	10	35	-15	60
5	10	30	-10	50
6	12	40	-15	60

Table A.2 Shunt capacitor data

Bus no.	Susceptance
10	19
24	4

Table A.3. load data

Bus No.	Load P (MW)	Load Q (MVAr)	Bus No.	Load P (MW)	Load Q (MVAr)
1	0.00	0.00	16	3.50	1.80
2	21.7	12.7	17	9.00	5.80
3	2.40	1.20	18	3.20	0.90
4	7.60	1.60	19	9.50	3.40
5	94.2	19.0	20	2.20	0.70
6	0.00	0.00	21	17.5	11.2
7	22.8	10.9	22	0.00	0.00
8	30.0	30.0	23	3.20	1.60
9	0.00	0.00	24	8.70	6.70
10	5.80	2.00	25	0.00	0.00
11	0.00	0.00	26	3.50	2.30
12	11.2	7.50	27	0.00	0.00
13	0.00	0.00	28	0.00	0.00
14	6.20	1.60	29	2.40	0.90
15	8.20	2.50	30	10.6	1.90

Table A4. line data

Line No.	From Bus	To Bus	Series Impedance (p.u) R	Series Impedance (p.u) X	Half Line Charging susceptance (p.u.)	Tap Setting	MVA Rating	Annual Cost (KS/year)
1.	1	2	0.01920	0.05750	0.02640	-	130	216.6125
2.	1	3	0.04520	0.18520	0.02040	-	130	307.2875
3.	2	4	0.05700	0.17370	0.01840	-	65	509.9500
4.	3	4	0.01320	0.03790	0.00420	-	130	700.0000
5.	2	5	0.04720	0.19830	0.02090	-	130	721.5250
6.	2	6	0.05810	0.17630	0.01870	-	65	168.1750
7.	4	6	0.01190	0.04140	0.00450	-	90	474.3000
8.	5	7	0.04600	0.11600	0.01020	-	70	62.0000
9.	6	7	0.02670	0.08200	0.00850	-	130	130.2000
10.	6	8	0.01200	0.04200	0.00450	-	32	104.6250
11.	6	9	0.00000	0.20800	0.00000	1.0155	65	306.9000
12.	6	10	0.00000	0.55600	0.00000	0.9629	32	20.9250
13.	9	11	0.00000	0.20800	0.00000	-	65	83.7000
14.	9	10	0.00000	0.11000	0.00000	-	65	927.6750
15.	4	12	0.00000	0.25600	0.00000	1.0129	65	554.1250
16.	12	13	0.00000	0.14000	0.00000	-	65	15.1125
17.	12	14	0.12310	0.25590	0.00000	-	32	30.2250
18.	12	15	0.06620	0.13040	0.00000	-	32	97.6500
19.	12	16	0.09450	0.19870	0.00000	-	32	179.0250
20.	14	15	0.22100	0.19970	0.00000	-	16	124.7750
21.	16	17	0.08240	0.19320	0.00000	-	16	146.4750
22.	15	18	0.10700	0.21850	0.00000	-	16	80.6000
23.	18	19	0.06390	0.12920	0.00000	-	16	235.6000
24.	19	20	0.03400	0.06800	0.00000	-	32	186.0000
25.	10	20	0.09360	0.20900	0.00000	-	32	117.8000
26.	10	17	0.03240	0.08450	0.00000	-	32	167.4000
27.	10	21	0.03480	0.07490	0.00000	-	32	160.4250
28.	10	22	0.07270	0.14990	0.00000	-	32	195.3000
29.	21	22	0.01160	0.02360	0.00000	-	32	166.2375
30.	15	23	0.10000	0.20200	0.00000	-	16	100.7500
31.	22	24	0.11500	0.17900	0.00000	-	16	40.3000
32.	23	24	0.13200	0.27000	0.00000	-	16	65.1000
33.	24	25	0.18850	0.32920	0.00000	-	16	210.8000
34.	25	26	0.25440	0.38000	0.00000	-	16	204.6000
35.	25	27	0.10930	0.20870	0.00000	-	16	83.7000
36.	28	27	0.00000	0.36900	0.00000	0.9581	65	223.2000
37.	27	29	0.21980	0.41530	0.00000	-	16	160.4250
38.	27	30	0.32020	0.60270	0.00000	-	16	90.6750
39.	29	30	0.23990	0.45330	0.00000	-	16	216.6125
40.	8	28	0.06360	0.20000	0.02140	-	32	54.2500
41.	6	28	0.01690	0.05990	0.00650	-	32	210.8000

Single line diagram shown in fig.1 is simulated in MI-power software package and standard data are entered. Then the load flow study is conducted. Table A.1 shows the details of the Generators that are present in the IEEE-30 bus system. There are 6 generators as shown, whose ratings are specified in MW. It is important to note that all these 6 generators are conventional diesel generators. Our aim in building this IEEE-30 bus system is to replace the least generating generators with the renewable source. The renewable source (Solar and Wind) are to be incorporated in place of conventional generators. This is the main reason behind us choosing IEEE-30 bus system for our analysis. IEEE-30 bus system stands as a benchmark base for most of the research happening around the globe [5], and moreover it has exactly the required number of generators for us to carry-out or project. Then the load flow study is conducted. Obtained result is shown below.

Table A.5

```
---------------- ----------
MW generation       298.0353
MVAr generation     120.2970
MW wind gen.          0.0000
MVAr wind gen.        0.0000
MW solar gen.         0.0000
MVAr solar gen.       0.0000
MW load             283.4000
MVAr load           126.2000
MVAr compensation     0.0000
MW loss              14.7203
MVAr loss            19.1131
MVAr - inductive      0.0000
MVAr - capacitive    25.0200
```

III. INTEGRATION OF SOLAR (NEGATIVE LOAD)

Solar energy is the radiant energy from the sun. Solar energy is converted into electrical energy by PV cells.

Here, the least generating generator is figured out as shown in table A.5

Table A.6

Gen No.	P1min (MW)	P1max (MW)	Q1min (MW)	Q1max (MW)
1	50	200	-	-
2	20	80	-20	100
3	25	50	-15	80
4	10	35	-15	60
5	10	30	-10	50
6	12	40	-15	60

The shaded part in the table A.5 i.e., 5th generator is replaced by negative load (solar). Thus, there will be 22 loads. Negative load is the one which infects power into the system instead of consuming the power. We have considered solar as negative load because the Negative load is considered to have the same effect as of the solar.

Thus load flow study is conducted and result is computed as shown in the table A.7. By looking at table A.7 we can conclude that the result obtained are similar to that of the conventional generators and solar system.

Table A.7

```
---------------- ----------
MW generation       263.9212
MVAr generation     110.0227
MW wind gen.          0.0000
MVAr wind gen.        0.0000
MW solar gen.         0.0000
MVAr solar gen.       0.0000
MW load             251.8000
MVAr load           122.7388
MVAr compensation     0.0000
MW loss              12.6652
MVAr loss             9.5910
MVAr - inductive      0.0000
MVAr - capacitive    22.3058
```

In the above table solar generation is shown as zero because negative load is replaced by 5th generator. MW loss is decreased because generator loss is compensated when it is replaced. We can also observe the change in bus voltage in the bus in which it is replaced by another generator.

Table A.8

```
 NODE     FROM    V-MAG
  NO.     NAME     p.u.
-----  --------  ------
    1     Bus1   1.0600
    2     Bus2   1.0597
    3     Bus3   1.0595
    4     Bus4   1.0552
    5     Bus5   1.0482
    6     Bus6   1.0491
    7     Bus7   1.0477
    8     Bus8   1.0488
    9     Bus9   1.0173
   10    Bus10   0.9544
   11    Bus11   1.0820
   12    Bus12   1.0326
   13    Bus13   1.0663
```

Table A.9

NODE NO.	FROM NAME	V-MAG p.u.
1	Bus1	1.0600
2	Bus2	1.0597
3	Bus3	1.0595
4	Bus4	1.0556
5	Bus5	1.0488
6	Bus6	1.0502
7	Bus7	1.0484
8	Bus8	1.0499
9	Bus9	1.0400
10	Bus10	0.9854
11	Bus11	1.1082
12	Bus12	1.0293
13	Bus13	1.0754

Table A.8 and A.9 shows the variation in bus voltages when conventional generator is replaced by solar. We can observe in 11th bus the voltage is increased from 1.082 pu to 1.1082 pu because there will be voltage instability when generator of lower capacity is replaced with solar.

IV. INTEGRATION OF WIND FARMS

Wind energy uses air flow to generate electricity. The velocity of the wind should be 2-3 m/s. These are least affected by weather conditions.

Table A.10

MW generation	264.3461
MVAr generation	114.6293
MW wind gen.	30.0000
MVAr wind gen.	0.0000
MW solar gen.	0.0000
MVAr solar gen.	0.0000
MW load	281.8000
MVAr load	126.8000
MVAr compensation	0.0000
MW loss	13.2091
MVAr loss	9.9234
MVAr - inductive	0.0000
MVAr - capacitive	22.0959

Here, the same generator is replaced with wind form i.e., 5th generator and load flow analysis is conducted for the same. The results are tabulated below.

From the above table we can observe that there is no much effect by replacing the least generator by wind. But there is a reduction in the dependency on the conventional generators.

Table A.11

NODE NO.	FROM NAME	V-MAG p.u.
1	Bus1	1.0600
2	Bus2	1.0598
3	Bus3	1.0595
4	Bus4	1.0564
5	Bus5	1.0497
6	Bus6	1.0521
7	Bus7	1.0497
8	Bus8	1.0518
9	Bus9	1.0861
10	Bus10	1.0189
11	Bus11	1.2221
12	Bus12	1.0482
13	Bus13	1.0936

From the above table, we can observe that there is increase in 11th bus voltage from 1.082pu to 1.2221pu because of voltage instability. After analyzing the effect due to solar and wind, a hybrid system is made by incorporating these RES in a single network. The result is tabulated below.

Table A.12

MW generation	204.7077
MVAr generation	109.1127
MW wind gen.	60.0000
MVAr wind gen.	0.0000
MW solar gen.	0.0000
MVAr solar gen.	0.0000
MW load	251.8000
MVAr load	122.7388
MVAr compensation	0.0000
MW loss	13.4469
MVAr loss	9.6574
MVAr - inductive	0.0000
MVAr - capacitive	23.2801

We can observe in 11th and 13th bus the voltage is changed from the default value. Because there will be voltage instability. The main reason for voltage instability is frequency deviation as generated frequency won't be 50Hz.

V. INTEGRATION OF HYBRID SYSTEMS.

By figuring out 2 least generating generators solar and wind farms are incorporated in the same system. The load flow study is done on this hybrid system is conducted and the results are tabulated as follows.

Table A.13

MW generation	204.7077
MVAr generation	109.1127
MW wind gen.	60.0000
MVAr wind gen.	0.0000
MW solar gen.	0.0000
MVAr solar gen.	0.0000
MW load	251.8000
MVAr load	122.7388
MVAr compensation	0.0000
MW loss	13.4469
MVAr loss	9.6574
MVAr - inductive	0.0000
MVAr - capacitive	23.2801

As tabulated in the table A.13 we can figure out that the MW generation due to wind is 60MW. Thus the hybrid system is successfully built in Mi-Power. We can observe in 11th and 13th bus the voltage is changed from the default value. Because there will be voltage instability.

VI. CONCLUSION

After analyzing the results of the hybrid system we can conclude that the Renewable energy resources are a good substitute for conventional energy generator [7]. Though RES has few negative impact when connected to the grid such as fault ride through, cascading of RES, reducing the harmonics and power fluctuations. These disadvantages can be over looked considering the advantages of RES, especially from environmental benefit point of view.

Table A.14

NODE	NAME	VOLT-MAG
1	Bus1	1.0600
2	Bus2	1.0598
3	Bus3	1.0595
4	Bus4	1.0561
5	Bus5	1.0492
6	Bus6	1.0509
7	Bus7	1.0489
8	Bus8	1.0507
9	Bus9	1.0539
10	Bus10	1.0066
11	Bus11	1.1214
12	Bus12	1.0622
13	Bus13	1.1394

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